

PHYTOTOXICOLOGY INVESTIGATIONS IN THE CORNWALL AREA OF ONTARIO  
IN THE VICINITY OF THE REYNOLDS METALS COMPANY (RMC), AND THE  
ALUMINUM COMPANY OF AMERICA (ALCOA),  
MASSENA, NEW YORK - 1984

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*Air Resources Branch*

*Phytotoxicology Section*

By: R. N. Emerson  
R. G. Pearson

Date: September, 1985

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**EXECUTIVE SUMMARY**

*A Federal-Provincial study with participation by several government agencies, including the Phytotoxicology Section, Ontario Ministry of the Environment, has been ongoing in the Cornwall area for several years.*

*Phytotoxicology investigations, involving vegetation sampling and injury observations, to assess the impact of airborne fluoride emissions from the Reynolds Metals Company (RMC) and from the Aluminum Company of America (ALCOA), both in Massena, New York, on vegetation in the Cornwall and Long Sault areas of Ontario, have been conducted during each growing season since 1969 and 1976, respectively.*

*The results of the most recent RMC and ALCOA survey study findings in 1984 are presented in this report.*

*In the RMC survey area, which includes the St. Regis Indian Reserve on Cornwall Island and extends to the north and northeast of the City of Cornwall, the highest fluoride levels in 1984 were, as in earlier years, detected in vegetation in the south shore - bridge area (the immediate impact area) of the*

island, with levels decreasing sharply with increasing distance from this area. Overall, fluoride levels in vegetation were higher in 1984 with some of the 1984 levels being the highest documented since 1977. The August maple foliage results for 1978 through 1984 revealed a trend of generally higher fluoride levels in recent years (1981-1984). Furthermore, in 1983 and 1984, fluoride injury was observed on a greater number of plant species than in previous years with the most adverse effects (as in all past years) being observed in or near the island's south shore - bridge area which is directly across the river to the northeast of RMC. However, comparisons of the foliar fluoride results which have been documented since RMC completed major abatement activity in 1972/73 revealed that even the highest fluoride levels detected in recent years are still lower than corresponding levels found in earlier years up until the mid-1970's.

In The Long Sault survey area, to the north and northeast of ALCOA, the degree of fluoride contamination of vegetation also was higher in 1984 than in most previous years. A corresponding increase in foliar injury severity also was documented.

In light of the 1984 weather data for the Cornwall area and the 1984 air monitoring program results on Cornwall Island in the RMC survey area, it is believed that dry weather during the growing season contributed to the increase in foliar fluoride contamination in both the RMC and ALCOA survey areas in 1984.

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I. INTRODUCTION

A Federal-Provincial study with participation by Environment Canada, Agriculture Canada, National Health and Welfare, Indian and Northern Affairs and the Ontario Ministry of the Environment was established in the Cornwall area in 1975. Prior to this time, the Phytotoxicology Section had been conducting annual vegetation assessment programs and responding to complaints concerning the adverse effects of airborne fluoride emissions on vegetation and cattle since 1969. The source of the fluoride emissions was identified as the Reynolds Metals Co., located in Massena, New York. The study was broadened in 1975 in view of the transboundary nature of the emissions and their impact on the St. Regis Mohawk Indian Reserve on Cornwall Island.

In 1976, the Phytotoxicology Section also initiated vegetation survey activity in the Long Sault area, downwind of the larger Aluminum Co. of America plant (ALCOA) located in Massena N.Y. to the west of the RMC plant.

Both of these vegetation assessment programs have been ongoing in the Cornwall and Long Sault areas without interruption since 1969 and 1976, respectively.

The results of the most recent 1984 study findings are presented in this report.

## II. RMC ASSESSMENT PROGRAM

### A. PRIMARY OBJECTIVE

To determine the degree and extent of fluoride contamination and injury to vegetation and to compare these findings with previous years' results.

### B. SAMPLES COLLECTED FOR CHEMICAL ANALYSIS

#### Maple Foliage

During late August, foliage was sampled from exposed middle branches of sixteen Manitoba maple sites sampled in 1983 on Cornwall Island and the Ontario mainland to the north and northeast of RMC (see attached Figure 1). As in 1983, triplicate samples were collected at each site. Foliage also was sampled in June and July at Site 1 near the south shore of Cornwall Island just east of the bridge, and in mid-July from a mainland site neighbouring the St. Lawrence River near St. Lawrence College to the northeast.

In addition to the samples of Manitoba maple, red maple foliage was collected monthly during June through August from the exposed southern periphery of the two woodlots on Cornwall Island to the west and east of the bridge. Slightly more remote to the northeast, red maple foliage also was sampled from the Lillian Point and Noah Point properties in June and August.

#### Other Species

Injured young staghorn sumac leaves from thickets near the south shore just west of the bridge, and corresponding healthy leaves from a more remote site near the R. Seymour forage site were collected in mid-July. During mid-September, current year's (1984) Eastern white pine needles were collected from the same pines sampled in previous years in the south shore area to the west and east of the bridge and from the more remote Elijah Benedict property near the centre of the island.

### Forage

With two exceptions (Cameron and RMC-17) forage was collected at all sites sampled in 1983 and from a new site (McGee property) situated on the mainland between the Farlinger site and former RMC-17 forage site. As in 1983, triplicate sampling at each site was conducted monthly during May through October. Overall, during the 1984 growing season, forage was collected from twelve sites on Cornwall Island and from three sites on the Ontario mainland including a remote site near Lunenburg (see attached Figure 1).

### C. SAMPLE PROCESSING AND SUBMISSION FOR ANALYSIS

All samples collected for chemical analysis first were processed in the Phytotoxicology processing laboratory and then were submitted for analysis on a dry weight basis to the Inorganic Trace Contaminants Section, Laboratory Services Branch, M.O.E.

The foliage and pine needle samples were processed on a washed and unwashed basis while the forage collections were processed as unwashed samples only. All samples were analyzed for fluoride and, in addition, the regular Manitoba maple collection in August and all other foliage samples collected from Cornwall Island during July and August were analyzed for aluminum and sodium.

### D. SAMPLES COLLECTED FOR HISTOPATHOLOGICAL EXAMINATION

In June and July, injured sumac foliage was collected from the south shore area just west of the bridge. In July, injured red maple foliage and sweet corn foliage from the Noah Point property and injured corn foliage from the L. Thompson property was collected. All above noted samples exhibited F-like foliar markings and were submitted for histological causal agent diagnosis.

#### E. VISUAL INJURY ASSESSMENT PROGRAM

*Injury assessment on native deciduous vegetation (cherry and maple trees, wild grape etc.) in the survey area was conducted monthly during June through August. Moreover, pine trees were examined on Cornwall Island and at several remote mainland sites as early as April with subsequent pine needle injury assessments being conducted on the island through to mid-September.*

*In addition, during July through August, vegetable crops were examined in twenty-two different gardens throughout Cornwall Island. On the island, cultivated grape plants growing on the following properties - A. Boots, Earny Benedict, N. Gaspary and A. Lazore - and mixed gladiolus varieties growing in the former Trailer site garden, Mrs. Leaf's garden and on the P. Thompson property also were examined for fluoride injury during July through August (see Figure 2).*

*In an effort to introduce a greater variety of perennial fluoride indicator plant species onto the island, three commercial plum varieties (Grenville, Mount Royal, Toka), a sand cherry and a red maple, all purchased from a commercial nursery, were planted on Cornwall Island in the immediate impact area just west of the bridge in late April, 1984. These plants were assessed for foliar injury on subsequent visits during the summer.*

*Snow Princess gladiolus indicator plots were not established in the survey area in 1984.*

*Dr. S.N. Linzon and R.G. Pearson, Phytotoxicology Section, MOE, and H. Lickers of the St. Regis Indian Band, accompanied the writer during an assessment of Cornwall Island vegetation on August 9, 1984.*

### III. RESULTS OF THE 1984 ASSESSMENT PROGRAM

#### A. ANALYTICAL RESULTS FOR FOLIAGE AND PINE NEEDLES

##### Manitoba Maple Foliage

As shown in Table 1, the highest fluoride levels in August were detected at Manitoba maple foliage collection Site 1 in the south shore-bridge area of the island, with foliar fluoride levels sharply decreasing with distance from this area. These findings were consistent with those of previous years.

Lower foliar fluoride levels were found at Site 1 in June and July. Table 2 (below) further shows that the degree of particulate surface contamination removed from the foliage by washing was higher in June than in July and August at the site.

Table 2  
Manitoba Maple Foliage  
- Fluoride Results - Site 1- 1984

Processing Method	Fluoride Concentration (ppm - dry wt. basis)		
	June*	July	August*
Not washed (NW)	200 (52%)**	119 (20%)	389 (22%)
Washed (W)	97	95	304

\*June and August values are means. A single sample was collected in July.

\*\* ( ) particulate removed by washing  $\frac{(NW - W)}{NW} \times 100\%$

The August particulate removal values for all collection sites are compared to corresponding earlier years' data in Table 1. This comparison revealed that the degree of particulate surface contamination washed from the foliage at most sites in August was lower than in 1983 and 1982.

In contrast to the lower percent removal values, fluoride levels in the unwashed foliage samples collected in August, 1984 generally were higher than the corresponding 1983 and 1982 results (Table 1). In comparing the August results detected over the past seven years (1978-1984), it is apparent that fluoride levels in unwashed Manitoba maple foliage in the survey area have been more elevated in recent years (1981-1984) with some of the 1984 levels being the highest documented since 1977 (Table 3). However, compared to 1977 and earlier years results, the 1984 levels are below those detected prior to and following abatement activity at RMC in 1972/73.

As with flouride, the highest aluminum and sodium levels in unwashed Manitoba maple foliage were detected at Site 1 in August (Table 4). The unwashed foliar concentrations of aluminum (80 ppm) and sodium (180 ppm) detected at this site in July were not as elevated.

The aluminum and sodium levels detected in unwashed Manitoba maple foliage collected throughout the survey area were, as in other years, variable in August and overall were not dramatically different from the corresponding 1981-1983 results (Table 4).

#### Red Maple Foliage Results

The unwashed (NW) and washed (W) foliar fluoride results for the red maple samples collected near the island's south shore to the west and east of the bridge during June through August and at the L. and N. point properties are presented in Table 5 (on the following page). In both south shore areas the highest fluoride levels were detected in August. The June through August foliar levels found just east of the bridge were, in all cases, higher than corresponding levels found to the west of the bridge.

Table 5  
Red Maple Foliage - Fluoride Results -  
South Shore - Bridge Area, 1984

Location	Fluoride Concentration (ppm - dry wt.)					
	June <sup>b</sup>		July <sup>a</sup>		August <sup>c</sup>	
	NW	W	NW	W	NW	W
West of Bridge	69	40(42%)*	73	64(12%)	134	120(10%)
East of Bridge	130	85(35%)	164	133(19%)	278	250(10%)
Lilian Point	63	37(41%)	-	-	-	-
Noah Point	-	-	-	-	172	157(9%)

a - based on a single sample

b - mean of duplicate sample results

c - mean of triplicate sample results

\* ( ) degree of particulate removed by washing  $\frac{(NW - W)}{NW} \times 100\%$

As with Manitoba maple foliage, a fairly high degree of particulate was washed from the samples collected in June (35-42%) whereas the particulate removal values for the red maple foliage samples collected in July and August were fairly low (9-10%).

Red maple foliage also was sampled in the south shore area to the west and east of the bridge in August, 1982 and the comparison of the 1982 and 1984 unwashed (NW) and washed (W) results is presented in Table 6 (page 8). This comparison shows that the degree of fluoride contamination of red maple foliage in these areas, particularly to the east of the bridge, was higher in 1984.

Table 6  
Red Maple Foliage - Fluoride Results -  
South Shore - Bridge Area - August 1984 & 1982

Location	Fluoride Concentration (ppm - dry wt.)			
	1984 <sup>c</sup>		1982 <sup>a</sup>	
	NW	W	NW	W
West of Bridge	134	120	118	80
East of Bridge	278	250	99	74

a - based on a single sample

c - mean of triplicate sample results

The aluminum and sodium results for the unwashed red maple foliage samples which were submitted for these analyses in 1984 are presented below in Table 7.

Table 7  
Unwashed Red Maple Foliage -  
Aluminum and Sodium Levels -  
Cornwall Island - July and August, 1984

Location in South Shore Area	Chemical Concentration (ppm - dry wt.)			
	July <sup>a</sup>		August <sup>c</sup>	
	Aluminum	Sodium	Aluminum	Sodium
West of Bridge	80	49	137	69
East of Bridge	82	93	220	183
Noah Point Property	-	-	157	120

a - based on a single sample

c - triplicate samples collected - values shown are means.



As with fluoride, the aluminum and sodium levels detected in the unwashed red maple foliage samples were the higher in August in the south shore area just east of the bridge.

#### Sumac Foliage Results

The fluoride results for the sumac foliage (NW-72 ppm; W-42 ppm) collected from the south shore-bridge area were about nine times higher than the levels found in the healthy sumac foliage (NW-8 ppm; W-5 ppm) sampled near the more remote R. Seymour property in July.

Concentrations of aluminum and sodium also were found to be higher in the sumac foliage (aluminum-68 ppm; sodium-130 ppm) from the south shore - bridge area than in the healthy foliage (aluminum-15 ppm; sodium-11 ppm) collected from the more remote sampling location.

#### Pine Needle Results

The fluoride levels detected in the unwashed (NW) and washed (W) current year's Eastern white pine needles collected from Cornwall Island in 1984 are compared to corresponding previous years' results in Table 8 below.

Table 8  
Fluoride Levels in Current Years'  
White Pine Needles Collected in 1982 through 1984

Sampling Location	Fluoride Concentration (ppm - dry wt. basis)					
	1982 <sup>c</sup> Sept. 4		1983 <sup>b</sup> Aug. 8-10		1984 <sup>a</sup> Sept. 13	
	NW	W	NW	W	NW	W
South Shore Area -						
West of Bridge	41	20	20	14	36	21
East of Bridge	59	30	21	21	34	34
Centre of Island -						
E. Benedict	23	11	6	5	11	10

a - based on a single sample

b - mean of duplicate sample results

c - mean of triplicate sample results

As with Manitoba maple, red maple and sumac, the highest fluoride levels were detected in the pine needles from the south shore - bridge area closest to RMC.

In contrast to the maple foliage results, fluoride levels in the current year's pine needles collected from the island in 1984 were slightly lower than the 1982 results. Unlike 1982 and 1984, the pine needle collection at the previously noted sites in 1983 was conducted in early August and hence the 1984 and 1983 results are not directly comparable.

B. COMPARISON OF UNWASHED DECIDUOUS FOLIAGE RESULTS TO FOLIAGE GUIDELINES ESTABLISHED BY THE PHYTO-TOXICOLOGY SECTION

Revisions to Former Phytotoxicology Excessive Levels in 1984

In 1984, the former Phytotoxicology Section excessive levels for contaminants in unwashed deciduous foliage were revised and the new guidelines, referred to as "upper limits of normal", were derived by calculating the mean of all available background data in Ontario plus three times the standard deviation.

The upper limit of normal for fluoride in unwashed foliage for rural and urban areas was calculated to be 15 and 35 ppm, respectively, with the urban guideline being unchanged from the former Phytotoxicology excessive level. The new guideline for aluminum in unwashed foliage for both a rural and urban area is 500 ppm whereas the upper limit of normal calculated for sodium in unwashed foliage for a rural and urban area is 50 ppm and 350 ppm, respectively. The former Phytotoxicology excessive levels for aluminum and sodium were 400 and 600 ppm, respectively.

Fluoride

Fluoride levels in the unwashed foliage samples collected during June through August were above the 15 ppm limit at all sites but one, with the foliar levels detected in the south shore-bridge area of the island, to the immediate northeast of RMC, being the highest.

### Aluminum and Sodium

Even the highest aluminum levels in maple foliage from the south shore-bridge area were below the new aluminum guideline (500 ppm). The mean sodium level detected in unwashed foliage at most collection sites exceeded the corresponding rural guideline (50 ppm) with the mean sodium result detected in August at Manitoba maple collection Site 1 (480 ppm) in the south shore-bridge area also exceeding the 350 ppm sodium guideline for an urban area.

#### C. ANALYTICAL RESULTS FOR FORAGE

As in earlier years, the highest monthly fluoride levels in unwashed forage collected from the survey area were detected at the bridge site, in the south shore-bridge area of Cornwall Island, with levels generally decreasing with distance from this area (Table 9).

In comparing the six month (May - October) means with the corresponding growing season means for 1978 through 1983, it is apparent that fluoride levels in forage generally were higher in 1984 compared to 1983 and 1982. In addition, the growing season mean for both the Bridge (92 ppm) and Noah Point (36 ppm) forage sites was the highest detected at both sites since sampling over a six month period began in 1978. Prior to 1978, forage was collected only in June, July and August and any comparison to the pre-1978 results must be based on three month (June - August) averages.

A comparison of the June - August forage means with the corresponding results of more recent years (Table 10) further confirms that the degree of contamination increased at the Bridge and Noah Point sites in 1984.

However, the 1984 six month forage means were not dramatically different from other corresponding post-1977 growing season means. In comparing the three month (June - August) means for sites which have been sampled during the entire twelve year post-abatement period (1973-1984), it is apparent that even higher fluoride levels in forage were detected in earlier years (1973-1975).

D. COMPARISON OF THE FORAGE RESULTS TO MOE ONTARIO FORAGE CRITERIA.

At the Bridge forage site, where the highest monthly fluoride levels were found, the single month 80 ppm Ontario forage criterion was exceeded on four occasions (June, July, August and October). There also were four times when the mean of two consecutive monthly collections exceeded the respective 60 ppm criterion with the six month growing season criterion of 35 ppm also being exceeded at this site.

The six month 35 ppm criterion also was exceeded for the first time since sampling started in 1978 at the slightly more remote Noah Point forage site to the northeast. At this site, there also was an exceedance of the two month criterion (60 ppm).

Therefore, during 1984, there were a total of 11 exceedances of the Ontario forage criteria at the Bridge and N. Point sites compared to four in 1983 and three in 1982.

E. VISUAL FINDINGS

Vegetation Affected

By the end of August, F-like foliar injury had been observed on the following vegetation on Cornwall Island: black, choke and pin cherry; Manitoba, red and silver maple; staghorn sumac; plum; red pine; wild and domestic grape; sweet corn and gladiolus. In each case the most adverse effects were observed in or near the south shore -bridge area to the immediate northeast of RMC.

Wild Grape Assessment

In 1984, as in 1983, F-like injury on wild grape foliage was observed from the area of the J. Charrow property, to the immediate north of RMC, through to the area of the A. Lazore property (6.8 km NE of RMC) at the east end of the island (Figure 2).

As in previous years, by late August, the most severe injury observed on wild grape was confined to the south shore-bridge area directly across the river from RMC. In this area, as in 1982

and 1983, adversely affected wild grape plants displayed moderate (11-35%) to severe ( $> 35\%$ ) foliar injury with the most adverse effects being observed adjacent to the river to the west of the bridge. Beyond this area, the foliar injury observed at wild grape sites in the vicinity of the J. Charrow property through to the A. Lazore property was less severe being either trace ( $> 0 - 1\%$ ) or light (2-10%) in severity.

On the mainland, in the RMC survey area, F-like foliar injury of trace to light severity also was observed at some wild grape sites with the most pronounced effects being observed on well exposed grape foliage neighbouring maple collection Site 13 to the northeast. Generally, well exposed wild grape plants growing atop hawthorn bushes or in trees were more severely injured than vines close to the ground.

The injury severity observed on wild grape in the south shore-bridge area of Cornwall Island was unchanged from previous years. In contrast, the injury to grape observed at the centre and east end of the island in the vicinity of E. Benedict and A. Lazore, respectively, was believed to be slightly more severe than in recent years.

The extent to which F-like injury on wild grape was observed on Cornwall Island in 1984 was comparable to that observed in 1983. F-like injury to wild grape on the mainland to the northeast of RMC also has been observed in other years during the post abatement period.

#### Staghorn Sumac Assessment

During June through August, staghorn sumacs in the south shore-bridge area exhibited several compound leaves/leaflets with marginal black or dark brown necrosis and intercostal injury and savoying (wrinkled, cupped). These effects were observed throughout the summer on both young and mature leaves. As in 1983, the more adversely affected leaves displayed moderate to severe injury.

Similar foliar injury of lesser severity was observed on sumacs on the slightly more remote Lillian Point property to the northeast. Sumac thickets examined in locations more remote from these areas failed to display any peculiar injury. F-like injury was not observed by the writer on sumacs in the survey area prior to 1983.

#### Cherry and Plum Tree Assessment

The June through August observations in the south shore - bridge area revealed F-like foliar injury on a young black cherry growing near the river's edge to the west of the bridge, on pin cherry trees both to the west and east of the bridge, and on a young choke cherry growing at the southern periphery of the woodlot just east of the bridge. The young plum trees planted by the writer in this area in April exhibited F-like foliar injury by mid-June.

Slightly more remote from the immediate impact area, F-like foliar injury also was observed on black cherry and plum trees on the A. Boots property, on plum trees on the Lillian Point property, and on a pin cherry growing beside the river to the south of the Noah Point forage site.

Injured cherry and plum foliage exhibited reddish tan to brown marginal and/or tip necrosis. Also observed on injured cherry and plum foliage was leaf tissue abscising from affected leaves. Injured pin cherry leaves, in many cases, were savoyed.

By mid-August, injured black cherry trees displayed mainly light (2 - 10%) to moderate (11 - 35%) injury and some leaves with severe (> 35%) injury. The severity of F-like foliar necrosis observed on affected pin and choke cherry and plum trees overall was either trace (> 0 - 1%) or light in severity with the most severe injury being observed in the south shore - bridge area to the immediate northeast of RMC.

The severity of F-like foliar injury observed on injured cherry and plum trees during 1984 was comparable to that observed in 1983.

### Red and Silver Maple Assessment

Red maples growing in the south shore area to the west and east of the bridge displayed distinct F-like blackish tips and/or marginal injury on several leaves by mid-August with the most pronounced injury being observed on the trees growing near the exposed southern periphery of the woodlot just east of the bridge. In July and August, affected foliage on these trees exhibited light (2 - 10%) to moderate (11 - 35%) necrosis. Less severe injury in the trace (> 0 - 1%) to light (2 - 10%) categories was observed on the red maple foliage examined to the west of the bridge. Red maples growing on the slightly more remote A. Boots, Noah Point and Lillian Point properties to the north and northeast also exhibited trace to light F-like foliar injury by the end of August.

In August, F-like foliar injury of overall trace (> 0 - 1%) severity also was observed on a young silver maple growing near the south shore not far from maple collection Site 3 and on young silver maple trees growing on the A. Boots property closer to RMC.

The blackish F-like injury observed on red maples was distinct in 1984 and was considered to be more typical of fluoride injury than that observed in 1982 and 1983. The injury severity observed on the slightly more remote red maple foliage examined in the vicinity of the Lillian Point and Noah Point properties, close to the A. Boots property, was comparable to the 1983 and 1982 observations.

### Manitoba Maple Assessment

Visual observations in August at regular maple collection sites in the survey area, most of which are mature trees, revealed the most severe foliar injury at Site 1 in the south shore-bridge area. At this site, in August, both younger and older leaves displayed light (2 - 10%) to moderate (11 - 35%) injury whereas in July the injury was confined to the older leaves. The August observations at other mature collection sites, including the Manitoba maple on the A. Boots property situated about 600 m north of Site 1, revealed only some leaves with tip and/or marginal necrosis of overall trace to light (2 - 10%) severity.



However, unlike mature trees, by the end of August, young Manitoba maples across most of the island were fairly severely injured and displayed moderate to severe injury to both young and mature leaves. In July, when first noticed, the injury on affected young trees was confined to the youngest two or three leaves. A similar injury pattern also was observed on isolated young Manitoba maples growing on the Ontario mainland. Young trees at remote island locations as well as those affected on the mainland were as severely injured as the younger trees in the immediate area of RMC.

Fluoride levels detected in the Manitoba maple foliage sample, which consisted partly of injured leaves with light injury, collected on the mainland in mid-July were elevated but not high (unwashed - 27 ppm; washed - 25 ppm). Nor were the fluoride results for the unwashed (39 ppm) and washed (25 ppm) Manitoba foliage collected from the A. Lazore property on the island in late August considered to be high enough to result in the moderate to severe foliar injury observed on young Manitoba maples near this site.

Hence, the preceding observations and analytical results failed to suggest that young Manitoba maples were reliable indicators of fluoride injury in 1984. However, as mature Manitoba maples growing in the immediate area of RMC did appear to be more injured than more remote trees and as excessive fluoride levels were found in the maple foliage samples collected from the south shore - bridge area where classical F-like injury was observed on other vegetation, it is concluded that RMC emissions did contribute to at least some of the foliar injury that was observed in 1984 on Manitoba maples growing to the immediate northeast of RMC.

#### Pine Needle Assessment

The older 1984 needles on Eastern white and other pines growing in the Cornwall area as well as at locations well remote from RMC and ALCOA displayed considerable winter injury in April, 1984; hence, only the 1984 current year's needles on pines in the survey area were examined for fluoride injury during the 1984 growing season.



In 1984, no F-like injury was observed on the current year's needles of white pines examined on Cornwall Island, including the mature white pine growing across from the A. Boots property which displayed injured current and older needles on some diseased shoots in 1983.

On the Noah Point property, current year's needles on the Scot's pines were injury free; however, F-like injury was observed on the 1984 needles of several young red pines with the average injury to the affected needles being about 10%. These red pines were not observed in previous years.

All other pines examined on Cornwall Island in 1984, including red pines, failed to display any peculiar injury to the current year's needles.

#### Cultivated Grape Assessment

Cultivated grape plants on the A. Boots, Earny Benedict and A. Lazore properties and in the abandoned vineyard owned by N. Gaspary located just east of the R. Pearce forage site were examined in July and August.

In August, F-like injury of trace ( $> 0 - 1\%$ ) to extremely light ( $< 5\%$ ) severity was observed on some mature leaves at all but the A. Lazore location. The injury at affected sites was primarily confined to the leaf tips and was initially observed in mid-July. The injury severity at affected sites in August was similar to that observed at these locations in 1983.

#### Garden Crops Assessment

During July and August, F-like foliar symptoms were observed on sweet corn plants growing on the V. David, Lillian Point, Noah Point, A. Boots, L. Thompson, and L. Point properties to the neighbouring northeast of the south shore-bridge area, and on the J. Charrow property near the south shore to the immediate north (Figure 2).

In July, affected corn plants examined displayed one or two middle leaves with distinct bands of chlorotic-yellowish tissue on both sides of the midrib at or near the arch.

In August, the above noted injury was more pronounced with chlorotic mottling and tan coloured necrotic margins also being displayed by several corn plants on affected properties to the northeast.

Similar foliar symptoms were observed only on some corn plants on the J. Charrow property situated just across the river from RMC to the north with the overall injury observed here in August being very light and less severe than that observed elsewhere. The injury observed on affected corn plantings to the northeast in August was closer to moderate (11 - 35%) in severity. As the remote island plantings failed to display any characteristic fluoride injury symptoms (banding, mottling) or pattern and as the histological results discussed later were supportive of the observations, it is suspected that the F-like symptoms observed on sweet corn plantings to the neighbouring north and northeast of RMC were related to fluoride emissions. This (1984) was the first year that distinct F-like symptoms were noticed on corn plants in the survey area since the annual assessment of vegetable crops across Cornwall Island began in 1982.

Other garden crops examined across the island in 1984, as in other years, failed to display any injury which was believed to be related to fluoride emissions.

#### Gladiolus Assessment

Gladiolus plants in a small garden neighbouring the former trailer site near the south shore and J. Charrow residence were examined in July and August. Glads growing on the more remote Mrs. Leaf and P. Thompson properties also were assessed for injury in August. No gladiolus plantings were noticed throughout the larger area extending to the northeast.

By August, the more severely injured plants at all locations displayed only some mature leaves with F-like injury extending down one or both sides of the injured leaves with the injury severity observed at all locations being in the light (2-10%) to trace (> 0-1%) injury categories.

#### Other Observations

As in earlier years, cryolite-like white coloured surface deposits were noticed on exposed foliage of broadleaf vegetation growing in the south shore-bridge area during the June through August injury assessments.

This material was collected for identification in 1983 and 1981 and was found to consist primarily of aluminum.

#### F. RESULTS OF HISTOPATHOLOGICAL EXAMINATIONS

Histopathological examinations of the injured sumac foliage from the south shore-bridge area, of the injured red maple and sweet corn foliage samples from the Noah Point property, and of the injured corn foliage from the L. Thompson property, collected in July, confirmed the presence of fluoride injury on these samples. The cause of the injury to the sumac foliage collected in June could not be confirmed.

IV. RESULTS OF ENVIRONMENT CANADA AIR MONITORING PROGRAM  
AND METEOROLOGICAL ASPECTS - 1984

As in 1983, Environment Canada (Pollution Measurement Division) maintained three air monitoring stations on Cornwall Island and a wind recorder at Station C at the west end of the island during the 1984 growing season. At least two air monitors (Station A - Customs area; Station B - E. Benedict property at centre of island) have been maintained annually in the survey area since 1976. The complete synopsis of the 1984 Environment Canada air monitoring program on Cornwall Island is attached for reference.

During the 1984 growing season, Environment Canada found a reduction in the number of exceedances of the air quality limits developed by the Canada (Federal) and Ontario (Provincial) government at Stations A and B compared to 1983, with the levels of particulate fluorides at all three locations declining to the record low levels found in 1982. At Station C, levels of gaseous fluorides were moderately increased compared to most other years, but no air quality limits for fluorides set by any agency were exceeded at Station C where the lowest air concentrations were recorded. As in previous years, the New York State air quality standards for fluorides were not exceeded at any of the stations.

Environment Canada also found that winds were predominantly from the southwest and that the frequency of southwest winds recorded during the six month (May - October) sampling period was unchanged from 1983. The percentage of southwest, south and west winds recorded, and total rainfall and frequency recorded, at the Ontario Hydro Climatic Station, Cornwall, during the shorter four month May through August period are compared to corresponding earlier years' data in Table 11. These data also are presented since reference to meteorological aspects in previous years' Phytotoxicology reports have been based primarily on wind and precipitation results obtained from this station.

Table 11 shows that there was a slight reduction in the percentage of both southwest and south winds compared to 1983 and that during most of the past years west winds have prevailed during May through August.

The wind data discussed above represent different recording periods and the cut-off speed used by Environment Canada (3 km/hr) is higher than that used by Ontario Hydro (0 km/hr). These factors probably account for the discrepancy between the two data sets.

In Table 11, the rainfall measured at the Ontario Hydro Climatic Station during May through August is summarized and compared to the norms for these months and to corresponding previous years' data. These comparisons showed that in 1984 a wet spring was followed by a dry summer (above normal rainfall being received in May and below normal rainfall being recorded in June and July. Overall, less total rain was received in 1984 compared to that which had fallen during each of the previous three years.

Hence, in light of the preceding air monitoring and meteorological results, it would appear that the increase in fluoride contamination to vegetation found in the RMC survey area in 1984 was more likely related to dry weather than to any major change in fluoride emissions from RMC.

V. ALCOA ASSESSMENT PROGRAM - 1984

A. PRIMARY OBJECTIVE

To determine the degree and extent of fluoride contamination and injury to native vegetation and to compare these findings with previous years' results.

B. SAMPLING AND INJURY ASSESSMENT

During late August (as in other years), Manitoba maple foliage was collected from the exposed side of six collection sites in the Long Sault area to the north and northeast of ALCOA. As in 1983, triplicate samples were collected at each site. All samples were processed on a washed and unwashed basis and were submitted on a dry weight basis to the Inorganic Trace Contaminants Section, Laboratory Services Branch, MOE, to be analyzed for fluoride, aluminum and sodium.

During August, sensitive vegetation (e.g. wild grape, pines) in the survey area was examined for fluoride injury.

C. ANALYTICAL RESULTS (COMPARISON TO PREVIOUS YEARS' RESULTS AND TO MOE GUIDELINES)

Foliar fluoride levels (Table 12) detected at downwind collection sites (4, 6, 7, 8) to the northeast of ALCOA were markedly higher in 1984 compared to the results for all other years except the first year (1976) of the survey.

As in 1982 and 1983, the highest unwashed and washed foliar fluoride levels were found at maple Site 7 (9.6 Km NE of ALCOA) where the average fluoride level of the unwashed foliage (106 ppm) was at least two times higher than the highest corresponding result (39 ppm in 1983) found during all previous years at this site. The unwashed mean fluoride concentration detected at downwind Site 8 (48 ppm) and more remote Site 6 (41 ppm) also was not noticeably higher compared to most earlier years' results.

The August, 1984 unwashed foliar fluoride levels were excessive at downwind Sites 4, 6, 7 and 8 relative to the respective upper limits of normal (15 ppm - rural; 35 ppm - urban). In contrast, levels greater than 35 ppm were detected at only one or two locations in previous years.

Unlike the fluoride results, aluminum and sodium levels detected in the unwashed foliage at the six collection sites were not markedly different from the corresponding 1983 results with much higher levels having been documented during earlier years. Even the highest foliar levels of aluminum (110 ppm at Site 7) and sodium (70 ppm at Site 1) were not found to be appreciably elevated when compared to the respective upper limits of normal (aluminum - 500 ppm; sodium: 50 ppm - rural; 350 ppm - urban) which have been recently established by the Phytotoxicology Section.

D. VISUAL FINDINGS

The visual observations during August, revealed the most severe F-like injury ever observed on sensitive wild grape plants in the survey area in the vicinity of maple Site 7. These findings coincide with the detection of the highest degree of fluoride contamination of maple foliage at this site in 1984.

Unlike other years, wild grape plants examined near this site displayed several affected leaves with light (2 - 10%) or moderate (11 - 35%) injury and some with severe (> 35%) injury. Wild grape foliage examined near the other maple sites was less severely affected and exhibited trace (> 0 - 1%) to light (2 - 10%) foliar injury (as in other years). The injury observed near downwind collection Sites 4 and 8, situated to the west and east, respectively, of maple Site 7, also was judged to be slightly more severe in 1984. Most wild grape plants examined were growing in trees or atop shrubs. Other vegetation examined in the survey area did not display any foliar injury which was believed to be related to ALCOA emissions.

VI. SUMMARY OF RMC AND ALCOA SURVEY FINDINGS - 1984

A. The main findings for the RMC survey area can be summarized as follows:

1. RMC emissions, as in previous years, resulted in the highest fluoride levels in vegetation in the south shore - bridge area of Cornwall Island with levels generally decreasing with distance from this area.
2. Fluoride levels in unwashed maple foliage and forage from the survey area generally were higher in 1984, with levels at some of the closest sampling locations being the highest documented since 1977.
3. A comparison of the 1978-84 August unwashed maple foliage results revealed that foliar fluoride levels at locations to the NE and NNE have been slightly more elevated in recent years (1981 - 1984).
4. Unwashed fluoride levels found in August at most foliage collection sites exceeded the 15 ppm "upper limit of normal" established for a rural area by the Phytotoxicology Section, with contamination extending to the NNE and NE to a distance of at least 13 km.
5. There was an increase in the number of exceedances of the MOE forage criteria, with eleven being recorded in 1984 compared to four in 1983 and three in 1982. Nine of these exceedances were documented at the Bridge site (1.5 km NE). However, for the first time since forage sampling on a six month basis began in 1978, the growing season (6 month) and 2 month criteria also were exceeded at the more remote Noah Point forage site.
6. As in other years, white coloured surface deposits were observed on broadleaf vegetation in the south shore-bridge



area and, as in previous years, the highest levels of aluminum and sodium in unwashed foliage were found in this area.

7. Foliar fluoride-like injury was observed in 1984 on the same deciduous species injured in 1983. As in previous years, the most adverse effects generally were confined to the south shore - bridge area of the island to the immediate NE of RMC. Although some species, in some areas, appeared to be slightly more injured in 1984 compared to 1983, the 1984 observations did not reflect any dramatic change in the degree or extent of fluoride injury to deciduous vegetation.
8. On conifers, fluoride-like injury to current year's needles was observed only on young red pines on the Noah Point property located NE of the south shore - bridge area.
9. Of the numerous garden crops examined on Cornwall Island, F-like foliar symptoms were observed for the first time on sweet corn plantings located closest to RMC; all other species were free of any fluoride-like injury symptoms.

In conclusion, the degree and extent of fluoride contamination to vegetation, including forage, was increased slightly in 1984 with some of the 1984 levels being the highest documented since 1977. Although recent survey (1983 and 1984) findings revealed a greater number of injured plant species than in past years, the 1984 observations failed to reveal any significant change in the degree or extent of injury to most vegetation. The analytical results for 1978-1984 revealed that fluoride levels in vegetation have tended to be slightly higher in recent years (1981-84); however, when the results are compared to those over the longer 11-12 year period since RMC completed major abatement actively in 1972-1973, it is apparent that even the more elevated fluoride levels found in 1984 are still much lower than some levels found in earlier years.

On the basis of the wide ranging variability in the foliar fluoride levels over this 11-12 year period, it appears unlikely that the slight increase in fluoride contamination found in 1984 was related to any major change in emissions from RMC. The Environment Canada air monitoring results and Ontario Hydro weather data for 1984 support this conclusion and suggest that the increase was more likely related to below normal rainfall during the 1984 growing season.

B. The major findings for the ALCOA survey area can be summarized as follows:

1. Fluoride levels in unwashed maple foliage collected to the northeast of ALCOA at four downwind sites (4, 6, 7,8) in the Long Sault area were the highest recorded since the first year of the survey in 1976.
2. As in 1983 and 1982, the highest unwashed and washed foliar fluoride levels were detected to the NE at maple Site 7 where the average fluoride level of the unwashed foliage was at least two times higher than the highest result found during all previous years at this site.
3. Fluoride levels in excess of 35 ppm in unwashed foliage were detected at four sites in 1984 compared to only 1 or 2 sites in previous years.
4. The most severe fluoride injury ever recorded in the ALCOA survey area was found on sensitive wild grape foliage in the vicinity of maple Site 7 in 1984.

In conclusion, fluoride levels in maple foliage found in the Long Sault area of Ontario in 1984 were higher than most previous years' results with slightly higher levels being detected only in 1976 when the survey began. As the degree of fluoride contamination of vegetation in the RMC survey area also had increased in 1984, with the air monitoring results for Cornwall Island and

*the weather data for 1984 suggesting that dry weather conditions had played a causal role, it is believed that dry weather also was primarily responsible for the increase in fluoride contamination found in the ALCOA survey area.*

*PH77-Cornwall*

**TABLE 1 - Comparison of Unwashed and Washed Fluoride Levels (ppm) and of % Particulate Removal Values for all Common Maple Sites Where Foliage was Collected during August, 1982, 1983 and 1984**

Site No.	General Location*	Distance (Km) & Direction from RMC	August - 1982		August - 1983		August - 1984		Corresponding % Particulate Removal Values -		
			Unwashed <sup>a</sup> (NW)	Washed <sup>a</sup> (W)	Unwashed <sup>b</sup> (NW)	Washed <sup>b</sup> (W)	Unwashed <sup>b</sup> (NW)	Washed <sup>b</sup> (W)	1982	$\frac{NW-W \times 100}{NW}$ 1983	1984
1	S shore-bridge (Is)	1.5 NE	380	180	293 ± 15.3	173 ± 25.2	389 ± 35.2	304 ± 33.1	53	41	22
33	A. Boots (Is)	1.9 NE	-	-	123 ± 5.8	61 ± 12.3	117 ± 18.1	79 ± 8.6	-	50	32
3	P. Hopps (Is)	3.1 NE	70	48	97 ± 15.3	68 ± 17.0	113 ± 10.0	106 ± 16.4	31	30	6
6	E. Benedict (Is)	4.1 NE	28	20	48 ± 6.2	25 ± 3.8	57 ± 5.5	38 ± 7.0	29	48	33
13	Cornwall (M)	6.0 NE	57	24	57 ± 6.2	26 ± 2.5	68 ± 5.0	50 ± 1.5	58	54	26
7	A. Lazore (Is)	6.8 NE	15	15	37 ± 4.6	15 ± 4.6	39 ± 2.3	25 ± 2.5	0	59	36
14	Cornwall (M)	8.3 NE	28	12	37 ± 3.2	23 ± 6.6	40 ± 4.6	32 ± 5.7	57	38	20
19	NE of Cornwall (M)	9.7 NE	25	15	30 ± 8.7	19 ± 3.5	34 ± 1.7	27 ± 2.1	40	37	21
17	NE of Cornwall (M)	13.2 NE	26	14	36 ± 2.5	22 ± 0	33 ± 2.9	24 ± 3.0	46	39	27
2	Customs Area (Is)	2.0 NNE	25	13	57 ± 1.5	12 ± 3.5	63 ± 12.9	58 ± 4.6	48	79	8
4	Cornwall (M)	4.7 NNE	66	17	63 ± 9.1	22 ± 1.2	42 ± 5.6	29 ± 7.4	74	65	31
5	Cornwall (M)	6.4 NNE	18	12	21 ± 3.1	12 ± 2.5	26 ± 3.8	21 ± 2.3	33	43	19
12	NE of Cornwall (M)	8.5 NNE	28	13	27 ± 1.7	10 ± 0.6	38 ± 2.1	26 ± 2.5	54	63	32
8	J. Thompson (Is)	1.9 N	12	8	27 ± 4.2	14 ± 4.0	23 ± 4.2	18 ± 2.3	33	48	22
9	R. Seymour (Is)	2.5 N	18	15	19 ± 1.0	13 ± 1.2	14 ± 2.5	12 ± 1.0	17	32	14
20	S shore - E end (Is)	6.1 ENE	17	12	31 ± 1.2	14 ± 3.8	41 ± 2.9	28 ± 4.0	29	55	32

\* (Is) - Cornwall Island; (M) - Mainland

a - based on a single sample; b - average of triplicate results ± std. deviation.

**TABLE 3 - Fluoride Results for Unwashed Manitoba Maple Foliage Collected in the Cornwall Area near the End of August: 1972-1984**

Site No.	Site Location Is - Island M - Mainland	Approximate Distance (Km) and Direction from RMC	** Average Unwashed Fluoride Concentration (ppm - dry wt.)												
			1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982 <sup>a</sup>	1983 <sup>a</sup>	1984 <sup>a</sup>
1	E of Bridge - S. Shore (Is)	1.5 NE	451	597	516	1,171	550	750	193	197	143	192	380	293	389
33	A. Boots (Is)	1.9 NE	-	-	-	-	-	-	-	-	-	-	-	123	117
3	P. Hopps (Is)	3.1 NE	-	-	-	-	122	217	32	57	60	86	70	97	113
6	E. Benedict (Is)	4.1 NE	317	244	98	235	114	56	22	32	23	71	28	48	57
13	Cornwall (M)	6.0 NE	-	-	-	-	-	-	16	29	15	64	57	57	68
7	A. Lazore (Is)	6.8 NE	90	-	79	100	116	37	23	21	15	64	15	37	39
14	Cornwall (M)	8.3 NE	-	-	-	-	-	-	17	14	10	44	28	37	40
19	Cornwall (M)	9.7 NE	-	-	-	-	-	-	18	18	20	50	25	30	34
17	Cornwall (M)	13.2 NE	-	-	-	-	-	-	11	13	25	39	26	36	33
2	Customs (Is)	2.0 NNE	-	-	-	-	123	138	17	31	10	50	25	57	63
4	Cornwall (M)	4.7 NNE	-	-	-	-	-	-	29	34	45	45	66	63	42
5	Cornwall (M)	6.4 NNE	-	-	-	-	-	-	21	19	25	46	18	21	26
12	Cornwall (M)	8.5 NNE	-	-	-	-	-	-	25	42	10	74	28	27	38
8	J. Thompson (Is)	1.9 N	30	-	76	60	29	45	15	21	8	18	12	27	23
9	R. Seymour (Is)	2.5 N	-	-	-	66	31	14	7	15	5	26	18	19	14
20	E end of Island (Is)	6.1 ENE	-	-	-	-	-	-	6	15	3	29	17	31	41

<sup>a</sup> Ion selective electrode method used; prior to 1982 the Alkali fusion method was used.

<sup>\*\*</sup> Averages for 1975-79; 1983-84 are based on triplicate collections. A single composite sample was collected at each site in 1980-1982 and prior to 1975.

TABLE 1 - Levels of Aluminum and Sodium in Onwashed Manitoba maple  
Foliage Collected in August from 1981 through 1984.

Site No.	General Location*	Distance (km) & Direction from RMC	Concentration - parts per million - dry weight							
			Aluminum				Sodium			
			1981 <sup>a</sup>	1982 <sup>a</sup>	1983 <sup>b</sup>	1984 <sup>b</sup>	1981 <sup>a</sup>	1982 <sup>a</sup>	1983 <sup>b</sup>	1984 <sup>b</sup>
1	S shore-bridge (Is)	1.5 NE	190	174	181	193	202	520	373	480
33	A. Boots (Is)	1.9 NE	-	-	131	130	-	-	253	287
3	P. Hopps (Is)	3.1 NE	101	74	99	107	180	245	157	223
6	E. Benedict (Is)	4.1 NE	125	32	79	69	137	112	107	109
13	Cornwall (M)	6.0 NE	129	98	123	160	130	125	127	267
7	A. Lazore (Is)	6.8 NE	334	70	110	103	90	48	67	95
14	Cornwall (M)	8.3 NE	85	52	96	96	68	64	97	92
19	NE of Cornwall (M)	9.7 NE	134	100	121	153	125	128	103	83
17	NE of Cornwall (M)	13.2 NE	115	68	106	107	80	64	117	106
2	Customs-Island Rd. (Is)	2.0 NNE	146	96	128	83	93	132	70	85
4	Cornwall (M)	4.7 NNE	118	90	130	100	103	130	97	87
5	Cornwall (M)	6.4 NNE	94	43	75	57	115	66	70	70
12	NE of Cornwall (M)	8.5 NNE	202	111	79	125	100	53	57	74
8	J. Thompson (Is)	1.9 N	68	51	96	57	70	85	77	68
9	R. Seymour (Is)	2.5 N	52	49	66	26	73	125	43	61
20	S shore - E end (Is)	6.1 ENE	73	80	110	81	90	53	77	99

\* (Is) Cornwall Island

(M) Mainland Cornwall Area

a - based on a single sample collected at each site.

b - mean of triplicate results for each site.

**TABLE 9 - Monthly Fluoride Levels Detected in Unwashed Forage Collected on Cornwall Island and Mainland during 1984 and Corresponding Seasonal (May - Oct.) Means for 1978-1984.**

Site Location (in order of increasing distance from RMC)	Approximate Distance (Km) and Direction from RMC	Monthly Fluoride Concentration <sup>a</sup> (parts per million, dry weight)						Seasonal Mean Fluoride Concentration <sup>a</sup> 1978-1984 (parts per million, dry weight)						
		May <sup>d</sup>	June <sup>d</sup>	July <sup>d</sup>	Aug. <sup>d</sup>	Sept. <sup>**</sup>	Oct. <sup>d</sup>	1984 <sup>d</sup>	1983 <sup>d</sup>	1982 <sup>b</sup>	1981 <sup>b</sup>	1980 <sup>b</sup>	1979 <sup>d</sup>	1978 <sup>d</sup>
Bridge Site (uncut)	1.5 NE	28	86	92	190	72 <sup>d</sup>	83	92	52	41	68	52	51	58
N. Point (grazed)	2.0 NE	10	34	54	71	18 <sup>d</sup>	29	36	30	25	34	28	20	31
P. Hopps (grazed)	3.1 NE	7	35	17	57	11 <sup>d</sup>	22	25	19	13	35	17	11	17
Dump Site (hayfield)	3.3 NE	7	32	14	47	16 <sup>b</sup>	25	24	15	14	26	16	9	12
E. Benedict (grazed)	4.1 NE	5	19	8	41	8 <sup>d</sup>	14	16	18	12	25	14	12	12
R. Pearce (grazed)	4.6 NE	6	14	15	34	11 <sup>c</sup>	18	16	18	11	23	16	10	14
N. Hopps (hayfield)	5.7 NE	3	8	14	34	8 <sup>d</sup>	18	14	13	9	18	7	9	9
A. Lazore (hayfield)	6.8 NE	4	6	9	22	7 <sup>d</sup>	15	11	11	6	15	9	9	8
D. Farlinger - M (hayfield)	9.2 NE	3	6	9	24	-	15	11	11	9	-	-	-	-
*McGee - M (hayfield)	11.8 NE	2	5	5	20	-	4	7	-	-	-	-	-	-
P. Caldwell (hayfield)	1.8 NNE	5	15	10	29	11 <sup>d</sup>	18	15	12	13	-	-	-	-
J. Thompson (grazed)	1.7 N	4	11	9	25	8 <sup>d</sup>	18	13	11	10	22	12	10	12
R. Seymour (grazed)	2.5 N	2	7	7	15	9 <sup>b</sup>	11	9	9	7	21	7	6	8
W tip of Island (hayfield/grazed)	1.6 NNW	3	5	5	16	-	18	9	8	7	-	-	-	-
Lunenburg - M (hayfield)	17.7 WNW	<2	3	<2	5	-	3	<3	3	3	-	-	-	-

a - all 1984, 1983 and 1982 results based on Ion Selective Electrode method; Alkali Fusion Method used for analysis in 1978-81.

b - based on a single sample.

M - site on Mainland; all other sites are on the Island.

c - based on duplicate samples.

\* - new site in 1984.

d - based on triplicate samples, except some of September, 1984 sites.

\*\* - several samples of the September collection were accidentally discarded prior to analysis.

**TABLE 10 - Average (June - July - August) Fluoride Results for Unwashed  
Forage Sampled on Cornwall Island - 1969-1984.**

Site Location (order of increasing distance from RMC)	Approximate Distance (Km) & Direction	*Average Fluoride Concentration (parts per million - dry weight basis)																	
		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1982 <sup>a</sup>	1983 <sup>a</sup>	1984 <sup>a</sup>	
Bridge Site	1.5 NE	456	597	361	137	128	192	-	-	88 **	72	43	43	71	32	36	48	123	
L. Point; N. Point	2.0 NE	-	-	-	66	71	76	116	51	95	37	16	23	29	28	18	18	53	
P. Hopps	3.1 NE	-	-	-	-	-	-	-	32	30	20	9	18	37	23	10	18	36	
Dump Site	3.3 NE	-	-	-	-	-	-	-	-	-	13	6	12	26	21	9	10	31	
E. Benedict	4.1 NE	-	64	79	56	54	29	71	21	23	14	11	13	25	23	10	17	23	
R. Pearce	4.6 NE	-	-	-	-	-	-	-	-	-	14	10	15	22	21	8	17	21	
N. Hopps	5.7 NE	-	-	-	-	-	-	-	13	11	9	9	7	21	14	6	9	19	
A. Lazore	6.8 NE	-	-	-	11	14	13	21	11	13	9	8	7	15	13	5	7	12	
Customs - Island Road (1977-1981) P. Caldwell - 1982 on	2.0 NNE 1.9 NNE	-	-	-	-	-	-	-	-	19 **	15	8	11	22	-	-	-	-	
		-	-	-	-	-	-	-	-	-	-	-	-	-	15	8	7	18	
J. Thompson	1.7 N	-	-	-	11	36	26	72	6	19	8	10	11	15	14	7	9	15	
R. Seymour	2.5 N	11	18	14	7	-	28	38	7	14	6	5	8	17	11	5	7	10	
W. tip of Island	1.6 NNW	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6	9	

\*1969-1974; 1980-1982 averages based on a single composite sample collected at each site per month.

1975-1979; 1983-84 averages based on the results of triplicate samples collected monthly at each site.

\*\* average based on estimated level for June

a 1982-84 results based on Ion Selective Electrode method; in 1969 through 1981, the Alkali Fusion method was used



**TABLE 11: Percentage of Time Winds were from the S, SW and W and Total Precipitation and Number of Days with Rain Recorded at the Ontario Hydro Climatic Station, Cornwall - May through August, 1978-1984.**

Year	MAY				JUNE				JULY				AUGUST				MAY-AUGUST*			
	% Wind			Rain (mm)	% Wind			Rain (mm)	% Wind			Rain (mm)	% Wind			Rain (mm)	% Wind			Rain (mm)
	S	SW	W	Tot Freq.	S	SW	W	Tot Freq.	S	SW	W	Tot Freq.	S	SW	W	Tot Freq.	S	SW	W	Tot Freq.
1978	6	19	31	79 10	6	23	28	71 17	5	33	28	51 9	6	27	25	102 11	6	25	28	303 47 (8)
1979	7	18	19	64 14	6	28	27	41 10	4	27	31	48 10	7	29	24	130 16	6 <sup>a</sup>	26 <sup>a</sup>	25 <sup>a</sup>	283 <sup>a</sup> 50 <sup>a</sup>
1980	6	19	23	39 7	3	17	33	38 12	5	25	33	114 19	5	21	22	137 13	5	21	28	292 49 (5)
1981	6	15	24	109 15	7	23	34	95 14	4	17	31	69 8	10	15	28	122 16	6	18	30	382 50 (5)
1982	9	11	19	58 8	5	23	20	86 14	2	24	34	66 10	3	23	33	125 12	5	20	26	324 42 (8)
1983	7	18	24	88 17	4	26	43	79 11	2	28	25	92 11	6	23	29	61 8	5	24	30	317 46 (4)
1984	3	17	39	113 18	4	22	38	55 8	2	26	48	51 11	2	23	34	95 14	3	21	40	296 47 (7)
Norms**				70 12				70 11				76 11				99 11				

\* May through to and including date of regular maple foliage collection near end of August - 1978 - Aug. 29; 1979<sup>a</sup> - Sept. 5; 1980 - Aug. 27; 1981 - Aug. 26; 1982 - Aug. 25; 1983 - Aug. 23; 1984 - Aug. 23. a - 1979 May - August\* values represent the period May - August 31.

\*\* Rainfall normals taken from Canadian Climate Normals, Atmospheric Environment Service, Environment Canada, Toronto.

(4) Number of days with rain during the two week period prior to maple collection.

**TABLE 12 - Analytical Fluoride Results for Unwashed Maple Foliage  
Collected in the Long Sault Area during 1976 to 1984.**

Site No.	Distance & Direction from LCOA	*Fluoride concentration - parts per million - dry weight								
		1976 Sept. 1	1977 Aug. 29	1978 Aug. 29	1979 Sept. 6	1980 Aug. 28	1981 Aug. 26	1982 Aug. 26	1983 Aug. 23	1984 Aug. 22
1	4.8 N	34	17	15	59	5 (3)**	22 (12)**	16 (10)**	26 (14)**	25 (17)**
2	7.9 NNE	13	11	6	11	5 (3)	13 (12)	6 (5)	17 (8)	12 (11)
4	9.5 NE	91	45	29	47	25 (20)	50 (16)	16 (13)	33 (16)	61 (25)
7	9.6 NE	-	35	38	30	15 (5)	34 (12)	28 (22)	39 (23)	106 (62)
6	12.6 NE	57	33	16	13	15 (5)	9 (7)	9 (5)	19 (11)	41 (20)
8	7.1 ENE	-	16	20	16	3 (3)	24 (12)	17 (10)	18 (11)	48 (29)

\* 1976-1979; 1983 and 1984 - average of triplicate samples.

1980-82 - based on a single sample.

\*\* ( ) fluoride concentration of washed foliage

Figure 1. Manitoba Maple Foliage And Forage Sites Sampled In The Reynolds Survey Area - 1984.

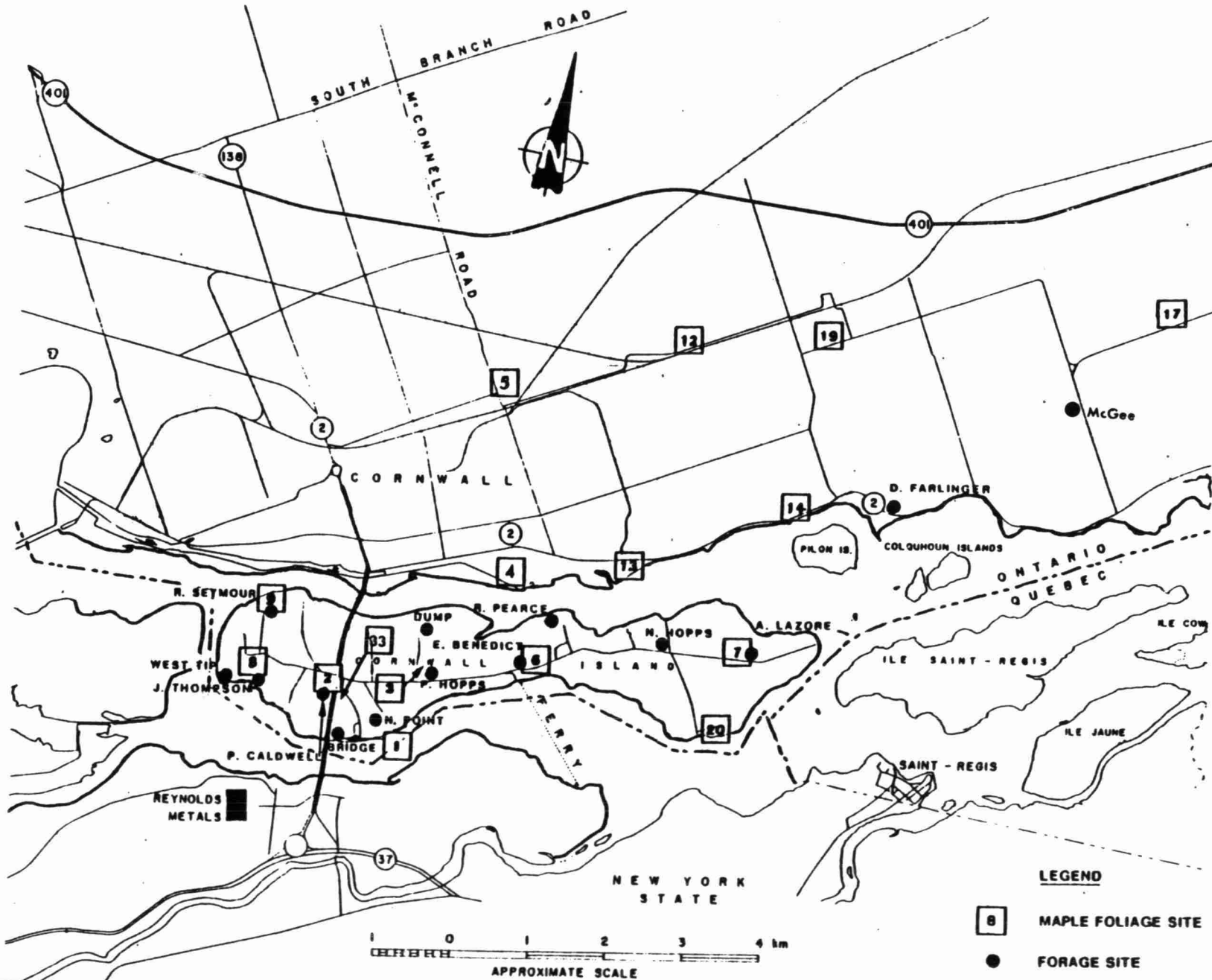


Figure 2: Approximate Location Of Other Foliar Collection Sites And Of Gardens Examined In 1984.

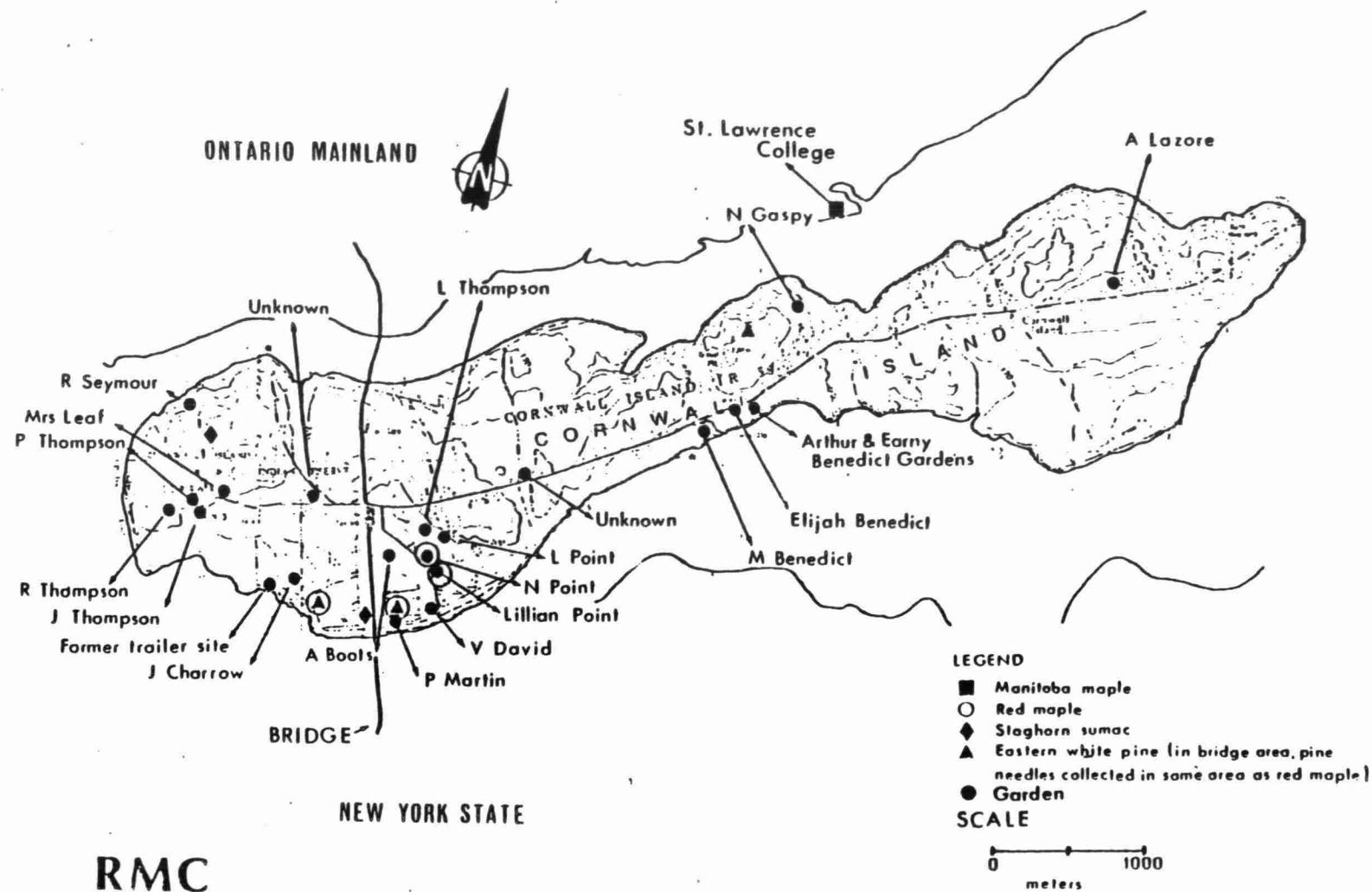
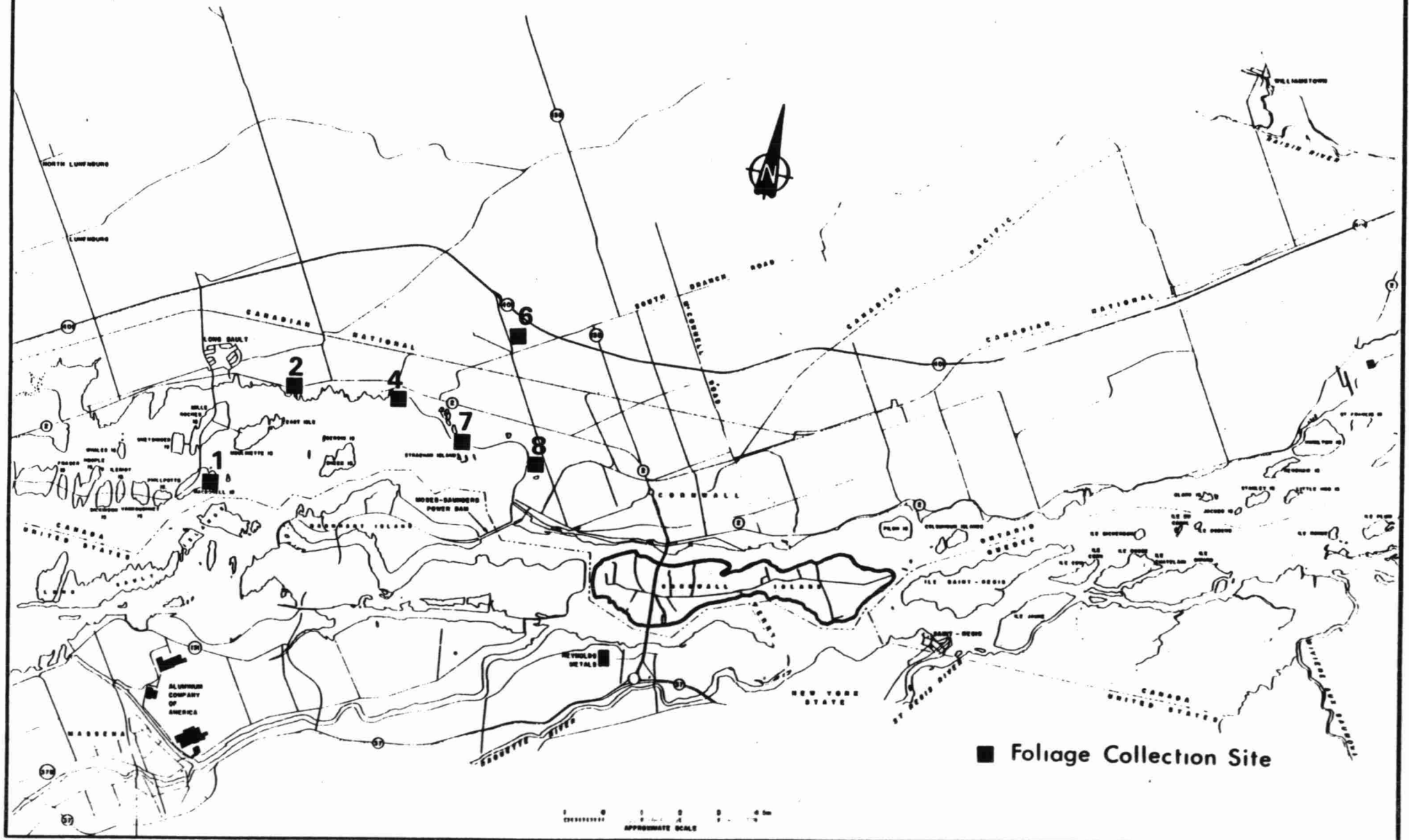


Figure 3. Maple Foliage Collection Sites In The Long Sault Area To The North And Northeast Of ALCOA--1984.



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AMBIENT AIR LEVELS OF FLUORIDE  
AT CORNWALL ISLAND, ONTARIO  
APRIL 15, 1984 - OCTOBER 15, 1984

*Environment Canada  
Pollution Measurement Division  
Report Released In 1985.*

## Synopsis

Examination of the historical summary of 24-hour average fluoride concentrations shows that the levels of particulate fluorides at all three stations declined to levels found in 1982 when record low concentrations were recorded. Gaseous fluoride concentrations at Station A and Station B however were found to be only slightly lower than in most other years while Station C recorded a moderate increase in gaseous fluorides. As in previous years, on the average, Station A recorded the highest particulate concentrations. Gaseous fluorides at Station A and Station B were approximately the same. The lowest concentrations of fluorides were recorded at Station C.

This year's growing season was monitored from May 2 to October 15 which lead to a significant increase of missing data compared to other years.

Gaseous fluoride concentrations greater than  $0.85 \text{ ug/m}^3$  were recorded on only five occasions at Station A. Last year there were 10 such occurrences. At Station B concentrations greater than  $0.85 \text{ ug/m}^3$  were recorded three times this year compared with four time last year. Station C again recorded no exceedances of  $0.85 \text{ ug/m}^3$ .

The New York State air quality standards for fluorides were not exceeded at any of the stations, as in previous years. Similarly, no air quality limits for fluorides set by any agency were exceeded at Station C. Exceedances of Ontario's criteria for air quality were markedly reduced at Station A and Station B. The most outstanding of these reductions appeared in exceedances of the 30-day gaseous limits. Station A recorded concentrations higher than  $0.32 \text{ ug/m}^3$  only 1.3% of the time compared with the historical average of 44.9%. Station B recorded concentrations greater than the above 9.1% of the time compared

to the average of 31.0%. These instances were however, more numerous than in 1982 when no exceedances were recorded. It is interesting to note that there were more violations of Ontario's 30-day gaseous limits at Station B this year than there were at Station A. This occurred during only two other years, 1980 and 1981, when winds were predominantly from the west. This year, winds were predominantly from the south-west in the same frequency as last year when a dramatic increase in frequency of predominated directions were noted. Canada's objectives for 7-day and 30-day gaseous fluoride concentrations were exceeded only at Station B, however the frequency was reduced when compared to other years. Canada's objectives for 70-day gaseous fluoride concentration were exceeded more frequently at Station A and Station B than in the two previous years. Overall, exceedances of the limits developed by the three agencies were reduced during the 1984 growing season.

As already noted, the winds were predominantly from the south-west this year. The frequency of these winds was the same as last year (30.7%). The pollution roses indicated a concentration of higher fluoride levels measured at Station A and Station B with winds blowing from the south to west direction.



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